



Cold Start

Cold-Start Test Description

Procedures for the cold-start tests were based on SAE Recommended Practice J1635*, "Cold-Start and Driveability Procedure." Cold startability was measured for each configuration in the range of -20 degrees F to +20 degrees F.

Cold-Start Test Preparations

In addition to the tasks indicated in *General Test Preparations*, the technicians performed the following pre-test tasks:

- It was confirmed that the viscosity rating of the engine oils was as recommended by the manufacturer for cold-weather operation.
- The strengths of the engines' coolants were measured to confirm that their protection levels were below -20 degrees F.
- The windshield washer fluid reservoirs and lines were drained completely.
- The vehicles' batteries were evaluated for charge levels and cranking capacities.
- A thermocouple was attached to each engine block.

Cold-Start Test Procedure

Each configuration was subjected to a series of cold-soak sessions, each followed by a cold-start procedure. These procedures were conducted in an insulated chamber conditioned by air-refrigeration equipment. The initial session for each configuration was conducted at -20 degrees F. If a particular configuration started successfully at -20 degrees F, a second, confirming session at -20 degrees F was conducted. If the configuration did not start successfully at -20 degrees F, iterative cold-room sessions were conducted at intervals of 5 degrees F to determine the configuration's cold-start temperature, +/- 2.5 degrees F. A data acquisition system recorded engine block and cold-room air temperatures throughout the cold-soak and cold-start periods. For all



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tests, the level of the specified fuel was maintained at or above one-quarter of the fuel tanks' capacity.

Prior to each cold-room session, a vehicle in the specified configuration was conditioned by driving it for a minimum of 10 miles at 45 to 55 mph. The vehicle was then placed in the cold-room, which had already been conditioned to the specified temperature. The vehicle's climate controls were set for windshield defrost at maximum temperature on the lowest fan speed and the engine was switched off. The engine block thermocouple was connected to instrumentation and a flexible exhaust hose was run from the vehicle's tail pipe to a port in the cold-room wall. The cold-room doors were sealed and the data-logging scan was initiated.

The cold-room includes an intake air make-up system in the form of a port through the wall to the outside. To prevent mixing of outside air with the conditioned cold-room air during the cold-start procedure, a set of flexible plastic bags was attached to the port on the inside of the wall and the bags were collapsed (or deflated). During the cold-soak period, the cold-room intake and exhaust ports were plugged with insulation and capped.

Because of the first-order asymptotic response of the engine block temperature to the step input of ambient temperature, the cold-room setpoint was adjusted to a few degrees below the target temperature in order to reduce the cold-soak time significantly. When the engine block attained the specified temperature, the setpoint was adjusted to the target temperature and approximately 1 h of additional soak time followed before the cold-start procedure began.

The refrigeration equipment maintained the cold-room air temperature in an approximate 4 degree dead band about the setpoint. Because of the large thermodynamic mass of the engine, the engine block temperature remained steady despite the fluctuation of the air temperature. Before entering the cold room to begin the start procedure, the temperature trend was monitored. When the trend became negative, the intake and exhaust ports were uncapped and the insulation plugs removed. As the air temperature dropped past the setpoint, technicians entered the cold-room and began the start test.

Engine starting procedures were those specified by the manufacturer in the vehicles' owner's manuals. An attempt to start the engine began while the cranking time was measured. If the engine did not fire within 15 s, cranking was stopped, and after 15 s of rest, a second attempt to start was made. If necessary, third and fourth attempts to start the engine were made following the same 15 s crank/15 s rest procedure. If the engine failed to fire, the configuration was judged to have failed the test at the particular temperature. The vehicle was then removed from the cold-room and allowed to soak at ambient temperature. After this soak, the vehicle was reconditioned and returned to the cold-room for the next session at a new target temperature.

If the engine successfully fired during any one of the attempts to start, the headlights and backlight defroster were switched on and the park idle speed quality was rated according

to the rating system specified in SAE J1635. If the engine idled successfully for 15 s, the vehicle's brakes were applied and the transmission was shifted to drive. If the engine stalled before the end of the 15-s park idle period, the start procedure was repeated. If the engine stalled three times, the configuration was judged to have failed the test at the particular temperature.

After shifting to drive, the drive idle quality was rated. If the vehicle idled successfully in drive for 10 s, the test ended with the configuration judged to have started successfully at the particular temperature. If the engine stalled before the end of the 10-s drive idle period, the engine was immediately restarted and allowed to idle in park for 15 s before shifting back to drive. If the engine stalled three times in drive, the configuration was judged to have failed the test at the particular temperature.

The total cranking time, the number of stalls, and the start and idle ratings were recorded. Start ratings range from 9 for best to 1 for worst and are based on cranking time with downgrades for stalls. Idle ratings range from 9 to 1 and are based on idle quality with downgrades for specific defects such as stalls, idle fluctuations, and after-run.

(View the [Cold Start Test Flow Chart](#).)

* Society of Automotive Engineers Surface Vehicle Recommended Practice, J1635, "SAE Cold Start and Driveability Procedure," Issued 1993-05-10.

[\[HOME\]](#) [\[TOP OF PAGE\]](#)